

**Some evolutionary and ecological implications of colour
variation in the sea urchin *Heliocidaris erythrogramma***

by

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I hereby declare that this thesis contains no material which has been accepted for the award of any degree or diploma in any university and that, to the best of my knowledge and belief, the thesis contains no copy or paraphrase of material previously published or written by another person, except where due reference is made in the text.

A handwritten signature in cursive script that reads "Jane Gowns." The signature is written in dark ink and is positioned above the printed name.

Jane Gowns

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ABSTRACT

An investigation into the evolutionary and ecological implications of variation in the external colouration of the sea urchin *Heliocidaris erythrogramma* was made. Two different pigment systems create a complex polymorphism; red granules of echinochrome A in the dermis occur in varying densities, and purple and green naphthoquinone pigments are found in the calcareous test and spines. Many morphs may occur within one population, but the proportions of morphs vary markedly between sites.

Evidence from the observed variability and chemistry of the pigments strongly indicates that the variation has a genetic basis. Breeding studies which would have resolved this question were unsuccessful, but did show that all crosses between morphs developed and metamorphosed successfully.

Repeated sampling of 15 sites showed that morph proportions were stable at most sites over the 35 months of the study. Geographic variation in the proportions of morphs was determined from samples from 49 sites. Environmental variables were recorded and the exposure of each site to wave action was estimated using algal communities to develop an Algal Exposure Index (A.E.I.). Stepwise linear regression analysis indicated that the A.E.I. and amount of algal cover were the only environmental factors noted that were useful predictors dermis colour proportions.

Five hypotheses were developed (two selective and three stochastic) of processes which might be affecting morph proportions in the study area; these were tested using Mantel's non-parametric test. The results suggest that four geographical regions each have different patterns of morph distribution which are controlled by unique combinations of selection (related to exposure) and gene flow. These results are generally supported by what is known of water currents in each region, as most gene flow in *H. erythrogramma* will occur due to movement of pelagic larvae.

Morphological data showed slight differences between urchins of different dermis colour at one site, but no differences between urchins with different coloured spines. There were significant differences between urchins at different sites. Surveys of urchin microhabitats indicated that (1) urchins of the same dermis colour tend to occur next to each other, (2) white dermis urchins tend to occur under rocks more often than red dermis urchins, and (3) urchins which are hidden under rocks tend to 'cover' with pieces of shell, algae or pebbles to a lesser extent than urchins which occur on the upper surfaces of rocks. A laboratory experiment indicated that, although the podia (tube feet) of red and white dermis urchins were initially of comparable strength, red dermis urchins tended to tire more quickly. No differences between morphs were found in the time of maturation of gonads or the size of gonads relative to body weight.

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